

Web-Hosted Software-Defined Radios

Amateur Radio operators are putting software-defined receivers online for anyone to use. This article describes some approaches.

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WebSDR websites allow shortwave listeners (SWL) and ham radio operators to use remote receivers located around the world, free of charge.

You can use WebSDRs in conjunction with your local transmitter, to listen on a WebSDR avoiding local noise, and transmitting from your home station.

A Web-Hosted Band-Dedicated Design

My own site, radiocheck.us, is a band-dedicated WebSDR site. It uses a long wire antenna to feed an eight-port HF receiver multi-coupler, enabling a single antenna to feed up to eight bands at the site (see Figure 1). Each amplifier feeds a hardware SDR, or direct-conversion receiver. The unity gain multi-coupler has 22 dB port-to-port isolation and provides impedance matching for 50 Ω SDRs. Band-pass filters are used between the multi-coupler and the SDRs to improve the dynamic range and sensitivity of the SDRs. I used the CloudIQ (24-bit) SDR for ham bands and AFEDRI SDR-Net (12-bit) for shortwave broadcast bands. The SDRs are configured for a band-pass of 500 kHz, yielding 31 Mbps IQ data streams from each SDR via a dedicated network to the radio server.

A web server is hosted independently from the radio site. Browsers are first directed to the web server, where web pages are downloaded and rendered on the user's computer

(see the sidebar, "Popular WebSDR Sites," for some options).

When users select a band, connections are established to the appropriate radio server for the delivery of pan display data and audio streams. Virtual receivers are created on the radio server to provide down conversion, filtering, demodulation, and all other radio services, including CW decoding and

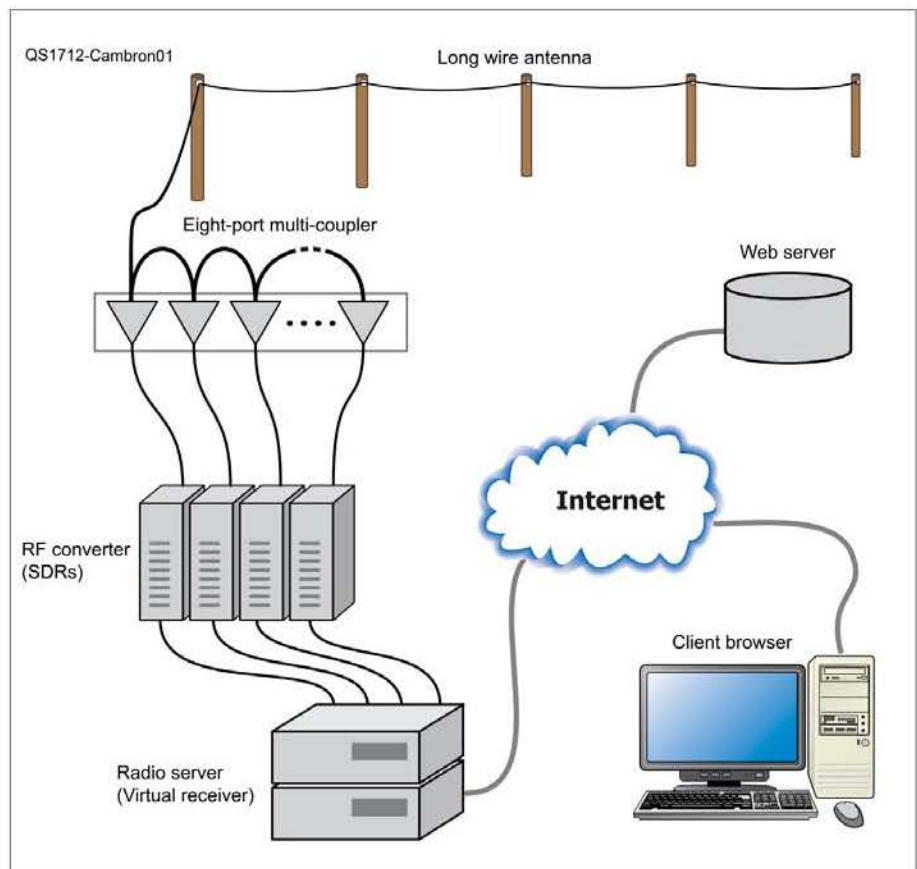


Figure 1 — Web-hosted software-defined radio (SDR) architecture.

WebSDR Characteristics

Various WebSDR sites have different designs and features.

User-dedicated SDR vs. band-dedicated SDR

User-dedicated SDR sites allow users sole control of an SDR from a receiver pool. The limited number of receivers limits the number of users. Band-dedicated sites allocate receivers to specific bands and use software to create virtual receivers for every user on that band, limited by the processing power and bandwidth of the site.

Sound card vs. direct IQ digital SDR

Sound card interfaces (used by SoftRock and other SDRs) are limited to 192 kHz bandwidth or less, thus most HF ham bands can't be covered by a single sound card SDR receiver. They also require multiple A/D conversion introducing additional quantizing distortion. Direct-conversion SDRs can have passbands of 2 MHz or more and cover most ham bands.

Depth of A/D conversion

Low-end SDRs, such as RTL2832s, are very inexpensive (around \$20) but provide only 8-bit sampling. High-end SDRs, such as CloudIQ, support 24-bit samples, resulting in lower quantizing distortion, better selectivity, and improved sensitivity. The signal-to-noise ratio (SNR) equals $6.02N + 1.76$ dB, so the improvement from $N = 8$ to 16 bits is significant, 50 dB vs. 98 dB. The improvement from 16 to 24 bits is imperceptible for most applications.

Community sites

Some sites invite community members to set up their own SDRs, and then the sites list them with links. Standardized SDR software is used to integrate the remote radios with the main site.

Note: Some sites require users to load plug-ins to enable access to the site. Plug-ins and dedicated software can provide higher-resolution graphics and lower sound latency, but are not always easy to load and use. Sites may also require registration, and a few charge fees.

All WebSDRs share a drawback over a local transceiver: latency. Audio delay for web-based radio is the sum of internet delay and audio coding/decoding delay. Most sites have brought latency down to the 1 – 3 second range, which is fine for everyday voice, RTTY, and PSK operation, but not suitable for CW contesting. Latency must be balanced against user bandwidth. Lower latency often means higher bandwidth. User bandwidth for a WebSDR session generally ranges between 150 and 250 kbps.

S-meter readings. Each virtual receiver connects to the SDR serving the selected band, tapping into the 31 Mbps IQ stream from the server. Browser-initiated tuning and control information are used to change settings on the virtual receiver. The filtered and demodulated 200 kbps audio stream from the virtual receiver is sent over the internet to the user's browser.

Figure 2 illustrates a typical direct-conversion receiver. A low-pass or band-pass filter at the front end eliminates unwanted signals before conversion. Analog variable gain amplifiers and sample/hold buffers

are used to pre-scale the signal to match the dynamic range of the A/D converter (ADC). The sampling rate of the ADC must accommodate the entire bandwidth of the front end, so for a 30 MHz SDR, rates of 80 Msps or 1 Gbps or greater are typical. The sampling rate of the quadrature mixer matches the tuned center frequency of the desired band, and is set by a numerically controlled oscillator (NCO). The mixer converts serial amplitude samples into in-phase and quadrature phase (IQ) samples. Digital filters downconvert the digital IQ signal to a baseband IQ signal at the desired bandwidth, 500 kHz in my design, which is set

by the sampling rate. Decimation is used to match the output sample rate to the desired Nyquist rate for the baseband signal.

The 31 Mbps IQ stream from the direct-conversion receiver terminates on the radio server, where it is processed by a dedicated software process, *iqradio*. As shown in Figure 3, the incoming data are duplicated into two streams. The first stream is sent to an IQ multi-cast group, which acts like a common bus, allowing all virtual receivers to attach and process the stream. The duplicate stream is processed using a fast Fourier transform (FFT), converting time-based data to frequency data. Those data are sent to a separate frequency multi-cast group. When users are directed to the radio server, a virtual receiver is created. The receiver joins the IQ data and frequency data multi-cast groups. Frequency data are scaled to match the user's selected frequency span and forwarded to the user's PC, where it is rendered as a pan display. IQ data

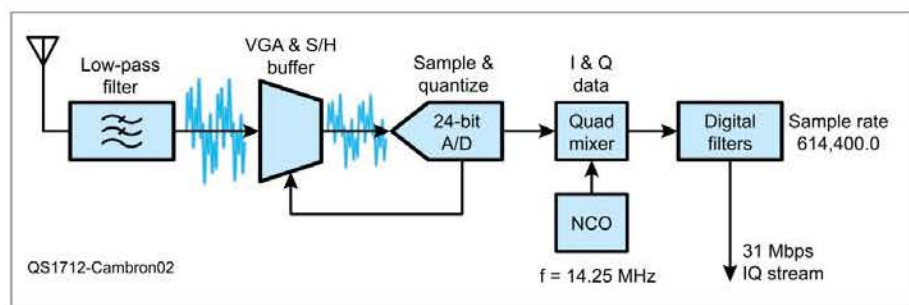


Figure 2 — A typical direct-conversion SDR design.

are downconverted, filtered, and demodulated before being forwarded to the user as audio.

The SDR stream of data is unaffected by the number of virtual receivers using that data. One SDR can serve one, 100, or 1,000 users, assuming there is sufficient processing power and bandwidth. The user controls the virtual receiver via an upstream message path, not shown on the diagram. Messages from the

user cause the virtual receiver to tune the downconverter, apply the proper filters, and select the correct demodulator (USB, LSB, CW). Audio volume is controlled at the user's PC.

Conclusion

The great attraction of many WebSDR sites is that you don't need to install any software or have a background in computer science to use them. Most sites are intuitive, designed to look like and operate like

a hardware radio. Many sites are free, and you can use them anywhere that you have access to a computer and the internet.

Keith Cambron, KC1ATT, was first licensed in 1980 as WA2YJL, and is a member of the Williamson County Amateur Radio Club. He received his BSEE from the University of Missouri, an MS in Systems Management from the University of Southern California, and a Software Programming Certification from the University of California at Berkeley. Keith retired as President and CEO of AT&T Labs, and is a retired Commander in the US Naval Reserve. He has taught C++ programming at Golden Gate University, and holds 11 patents for communication systems design. He has published articles in the refereed professional literature, and is author of the book *Global Networks: Engineering, Operations and Design*. Keith is a senior member of the IEEE, and has been profiled in *Telephony Magazine* and *America's Network*. He received *Telephony's* Fiber in the Loop design award for his work on HFC networks. Keith enjoys writing software and traveling. You can reach Keith at gkcambr@yahoo.com.

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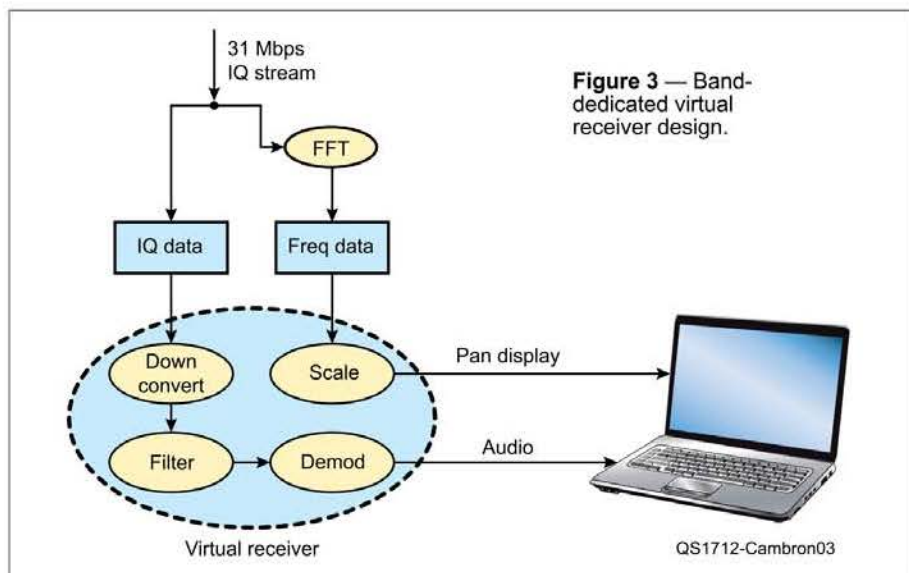


Figure 3 — Band-dedicated virtual receiver design.

Popular WebSDR Sites

sdr.hu — A free community site using common software platforms (*OpenWebRX* and *BeagleBone*) and common hardware, KiwiSDR or RTL-SDR. It hosts user-dedicated SDRs with over 120 sites worldwide, and usually four shared 12-bit ADC receivers at each site. Most sites cover the 1 to 30 MHz bands, with some supporting the 2-meter and 70-centimeter bands.

websdr.org — Another free community site primarily using band-dedicated sound card SDRs, such as SoftRock. These sites usually cover 96 or 192 kHz of selected amateur bands. Multiple SDRs are used at most of the sites for wider coverage. The site offers a Java plug-in for browsers that don't support HTML5.

WebSDR.ewi.utwente.nl:8901 — Operated by the radio club ETGD at the University of Twente in the Netherlands, this free site has a state-of-the-art custom FPGA wide-band direct-conversion SDR receiver with a 30 MHz passband in a dedicated band design. You can record your transmission for later analysis.

globaltuners.com — This community site uses computer-aided receivers (such as the Icom IC-PCR1000) with web-enabled controls, as well as RTL2832 SDRs. There

are about 80 sites around the globe. The site uses some plug-ins, such as Flash audio, and allows recording of your transmission for later analysis.

dxzone.com — A listing of individual WebSDR and computer-aided receiver sites.

remotehams.com — A community site that uses dedicated transceivers and receivers. The client (user) software is downloaded and installed on a Windows PC. Server-side software can also be downloaded to enable operators to add their radio to the community pool. Permission from the operator is often required to operate the radio remotely.

remotehamradio.com — A site for licensed amateurs. Registered users can operate one of the site's dedicated K3 transceivers for a per-minute charge. Well designed, with extensive tools including rotor controls, split operation, recording, and automatic logging.

streema.com/radios/genre/Ham_Radio — Really a free streaming audio service using 150 HF radios, repeaters, and scanners. There are no tuning controls or pan displays.